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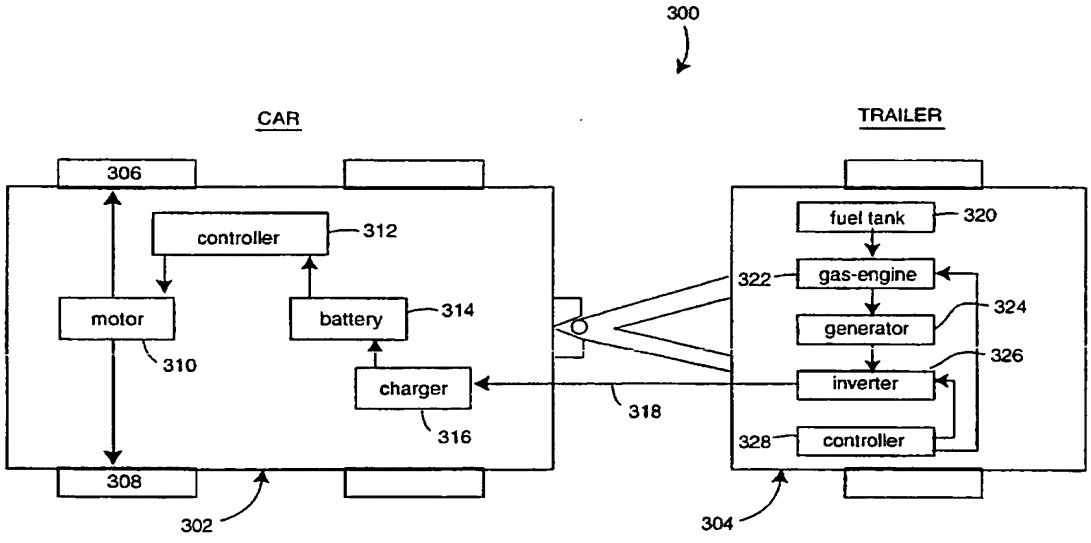
(54) Title: TRAILER FOR "IN-FLIGHT" POWERING AND RECHARGING OF ELECTRIC VEHICLES



(57) Abstract: A gasoline-engine driven generator (324) is mounted to a small car trailer (304) and can be towed behind an all-electric powered vehicle (302). The trailer provides operating power and recharging power "in-flight" while the vehicle is in use. It may also be operated in an unattended mode where a discharged electric vehicle can be recharged while parked. As such, an all-electric car is converted on an ad hoc basis to a gasoline-engine/electric hybrid. The range of the combination is limited only by the availability of gasoline and the trailer's gasoline storage capacity (320).

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TRAILER FOR "IN-FLIGHT" POWERING AND RECHARGING OF ELECTRIC VEHICLES

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to automobiles, and more particularly to electrically powered cars that include portable gasoline-engine driven electric generators to extend their operating range.

Description of Related Art

Getting completely away from the use of gasoline in cars is proving to be a very difficult challenge. All-electric cars have been known for quite some time. Several electric car manufacturing companies were all founded in the early 1900's, but all failed to capture the mass market. Concept cars appear to be the only current demonstration of hybrid gasoline-engine/electric automobiles. No major manufacturer is currently producing such hybrids and making them generally available to the public. A few are in the advanced stages of testing and selling all-electric cars, e.g., General Motors EV-1, Honda, Solectria, and some fleet vehicles from Ford. A few others have announced their good intentions in this field.

Bruce D. White describes an electric automobile in United States Patent 4,199,037, issued April 22, 1980. An electrically-powered vehicle combines an automobile frame and trailer which are driven by a pair of electric motors located on the automobile frame. A battery is also located on the automobile frame, and a generator, along with a gas turbine for driving the generator, are located on the trailer. The vehicle can be operated with the trailer

attached and the electric motors powered by a parallel combination of the battery and generator, or with the trailer removed and the motors powered by the battery alone. A controller turns on the gas turbine when the charge level in the battery drops below a first predetermined level, and it turns off the turbine when the charge level rises above a second predetermined level. When such gas turbine is running, its speed is held constant, in order to maximize its operating efficiency and to minimize exhaust pollution.

Louis W. Parker describes an electrically propelled automobile in United States Patent 3,690,397, issued September 12, 1972. Such car is provided with a detachable wheeled trailer unit which is housed entirely within the automobile body. The trailer unit carries batteries to power the car's electric motor, and its own motor can be powered by the battery units for self-propelling the trailer unit when it is not attached to the automobile.

Bjorn Ortenheim was issued United States Patent 5,251,721, issued October 12, 1993, for a semi-hybrid electric automobile. An all-electric car is provided with a bay in which a gasoline engine can be docked. Such engine literally plugs into the car when its use is needed and includes its own gas tank and transmission.

A similar design was patented by Albert Wild for a car that could accept "one of two types of power pods". United States Patent 3,497,027, issued February 24, 1970, describes such pods as including one with batteries and the other with an internal-combustion-engine driven generator. A special compartment is provided in the car to accept such pods according to the user's driving needs.

All such prior art designs involve compromises. Some appear very impractical to build and sell, and others seem too difficult for the average driver to really take advantage of the equipment. All-electric cars have a niche they can fill very well, e.g., regular commutes between home and work where one or both destinations allow a "plug-

in" to recharge. It is the occasional long commute, or one to destinations where a plug-in to recharge may not be possible, that frustrate electric car users. A typical family may only experience such a need only five percent of the time, one out of twenty trips. The usual answer is to have a regular gasoline-powered car on standby. But this can be expensive and seems to defeat the advantages promised by all-electric cars.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a take-along portable generating unit to extend the operating range of otherwise all-electric vehicles.

Another object of the present invention is to provide an alternative battery recharging source for electric vehicles.

Briefly, a gasoline-engine driven generator is mounted to a small car trailer that can be towed behind an all-electric powered vehicle. The trailer provides operating power and recharging power "in-flight" while the vehicle is in use. The all-electric powered vehicle does not necessarily need such trailer on short trips where the on-board battery storage of the car will be sufficient and where recharging plug-ins will be available. The trailer and car combination may be operated in an unattended mode where a discharged electric vehicle can be recharged while parked. As such, an otherwise all-electric car is converted on an ad hoc basis to a gasoline-engine/electric hybrid. The range of such combination is limited only by the availability of gasoline and the trailer's gasoline storage capacity.

An advantage of the present invention is that a power generator trailer is provided for an all-electric car that

can free the car to take long trips where electric utility power is uncertain, unavailable, or inadequate.

Another advantage of the present invention is that a power generator trailer is provided for an all-electric car that can allow the car to avoid the long recharging periods needed when connected to an electric utility for refreshing a completely discharged battery.

A still further advantage of the present invention is that a retro-fit power generator trailer is provided for a conventional all-electric car. This makes possible a hybrid retro-fit function without substantial change to the basic electric vehicle.

The above and still further objects, features, and advantages of the present invention will become apparent upon consideration of the following detailed description of specific embodiments thereof, especially when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a top phantom view diagram of a power-trailer system embodiment of the present invention which uses a single-point trailer hitch on the car and fixed wheels on the trailer;

Fig. 2 is a top phantom view diagram of a power-trailer system embodiment of the present invention which uses a dual-point trailer hitch on the car and steerable wheels on the trailer; and

Fig. 3 is a functional block diagram that represents the major assemblies of Figs. 1 and 2 and their working interrelationships.

DETAILED DESCRIPTION OF THE INVENTION

Fig. 1 illustrates a power-trailer system embodiment of the present invention, referred to herein by the reference numeral 100. The power trailer system 100 includes a power trailer 112 that attaches to a conventional all-electric vehicle 114. For example, the all-electric vehicle 114 can be a commercial vehicle as manufactured by Solectria Corporation, 33 Industrial Way, Wilmington, MA 01887-3433. Solectria markets the FORCE all-electric car which features smooth, quiet, shift-free operation, regenerative braking, a full-size trunk, and an onboard charger that uses a standard 110VAC or 220VAC utility power. A special controller is included for efficient driving and maximum battery life. An optional battery thermal management system improves the car's operating range in cold weather.

The car 114 has a conventional Class III trailer-towing hitch that provides for the attachment of an A-frame trailer tongue 116 on the power trailer 112. A lights and brake cable 118 connects the car's turn signal, stop light, running light, and electric brake circuits to the power trailer 112. A power umbilical cord 120 provides a 50-amp 220 VAC circuit from the power trailer 112 to an on-board automatic charger 122.

The car 114 has a front battery pack 124 and a rear battery pack 126 that supply operating power to a brushless motor 128. The speed of the car 114 is user controlled by an electronic motor controller and regenerative brake unit 130. A transmission 132 connects the motor 128 to a set of front wheels 134 and 136. The car 114 includes a set of rear wheels 138 and 140 that may or may not have a drive motor attached to them.

The power trailer 112 has a pair of wheels 142 and 144 that are fixed in the straight ahead direction. A power unit 146 includes a gasoline engine, a fuel tank, an electric generator, and an DC-AC power inverter connected

to the umbilical cord 120. A storage compartment 148 sits behind. The power trailer 112 is preferably colored and styled to match the car 114.

Fig. 2 illustrates a power trailer system embodiment of the present invention, referred to herein by the reference numeral 200. The power trailer system 200 includes a power trailer 212 that attaches to a conventional all-electric vehicle 214. For example, the all-electric vehicle 214 can also be a Solectria FORCE which has a trailer-towing hitch 215 that provides for the attachment of an dual-tongue trailer hitch 216 and 217 on the power trailer 212. A lights and brake cable 218 connects the car's turn signal, stop light, running light, and electric brake circuits to the power trailer 212. A power umbilical cord 220 provides a 50-amp 220 VAC circuit from the power trailer 212 to an on-board automatic charger 222.

The car 214 has a front battery pack 224 and a rear battery pack 226 that supply operating power to a brushless motor 228. The speed of the car 214 is user controlled by an electronic motor controller and regenerative brake unit 230. An automatic transmission 232 connects the motor 228 to a set of front wheels 234 and 236. The car 214 includes a set of rear wheels 238 and 240 that may or may not have a drive motor attached to them.

The power trailer 212 has a pair of pivotable wheels 242 and 244 that will automatically steer the turning radius determined by the car 214. This allows the user to backup the combination without and special skills in trailer towing. A power unit 246 includes a gasoline engine, a fuel tank, an electric generator, and an DC-AC power inverter connected to the umbilical cord 220. A storage compartment 248 sits behind. The power trailer 212 is preferably colored and styled to match the car 214.

The present invention allows for an equipment-rental business model in which a business makes available at least one power-trailer that can be temporarily fitted to an all-

electric car. A customer can then rent such power-trailer from the business for a period of time and attach it mechanically and electrically to the user's all-electric car. As described above, the power-trailer includes an internal-combustion engine that drives an electric generator and thus can provide battery recharging and operating power to the all-electric car through an umbilical cord.

Fig. 3 represents the systems 100 and 200 with a functional block diagram. An electric car and power wagon embodiment of the present invention is referred to in Fig. 3 by the general reference numeral 300. The electric car and power wagon 300 includes an all-electric car 302 that tows a two-wheeled trailer 304 whenever extended range is needed and/or electric utility plug-ins will not be available, or their availability is uncertain. The trailer 304 could be rented for temporary use or shared amongst several vehicles 302. A pair of front wheels 306 and 308 are driven by a powerful electric motor 310 capable of efficiencies on the order of one hundred thirty-seven watt-hours per mile, and with a top speed of seventy miles per hour. A controller 312 meters power from a battery 314 capable of 42,000 watts at one hundred eighty volts, for example. An on-board charger 316 allows 110/220 VAC household utility power to be used to recharge the batteries 314. A power umbilical cord 318 allows power to be transferred from the trailer 304 while in motion. A fuel tank supplies gasoline or other petrochemical fuel to an internal combustion engine 322. This drives an electric generator 324 and power inverter 326 sized large enough to recharge the batteries 314 even during top-speed operation. A controller 328 monitors the battery voltage of batteries 314 and regulates the power delivered. It also turns the engine 322 on and off such that pollution is minimized.

Although particular embodiments of the present invention have been described and illustrated, such is not intended to limit the invention. Modifications and changes

will no doubt become apparent to those skilled in the art, and it is intended that the invention only be limited by the scope of the appended claims.

THE INVENTION CLAIMED IS

1. A power-trailer for use with an all-electric car, comprising:

a detachable car trailer for temporary connections to an all-electric car;

an electrical umbilical cord that provides electrical power to said all-electric car from the car trailer;

an internal-combustion engine and an associated petrochemical fuel storage mounted to the car trailer; and

an electric generator mounted to the car trailer and connected to be driven by the internal-combustion engine;

wherein, the electric generator provides battery recharging and operating power to said all-electric car through said umbilical cord.

2. The power-trailer of claim 1, further comprising:

an electrical-power inverter mounted to the car trailer providing for a conversion of electrical power from the electric generator to a form that is compatible with the all-electric car.

3. The power-trailer of claim 1, further comprising:

a set of pivotable wheels for carrying the weight of the car trailer over a road; and

a double attachment between the car trailer and said all-electric car providing for simplified back-up maneuvers of said all-electric car;

wherein the double attachment allow the all-electric car to automatically steer the wheels when traveling.

4. The power-trailer of claim 1, further comprising:

an automatic control system connected to the internal-combustion engine providing for on-off operation of the electric generator according to an electrical power demand of the all-electric car.

5. The power-trailer of claim 1, further comprising:

a set of batteries mounted to the car trailer and providing for reserve electrical operating power for the all-electric car.

6. The power-trailer of claim 1, further comprising:

a general purpose storage compartment mounted to the car trailer and providing space for equipment related to the use of the all-electric car.

7. The power-trailer of claim 1, further comprising:

a trailer hitch providing for quick and simple mechanical attachment of the car trailer to the all-electric vehicle; and

an electrical connector and cable included in the umbilical cord and providing for quick and simple electrical attachment of the car trailer to the all-electric vehicle.

8. The power-trailer of claim 1, wherein:

the car trailer is colored and body-styled to match a color and body style of the all-electric vehicle.

9. A power-trailer for use with an all-electric car, comprising:

a detachable car trailer for temporary connections to an all-electric car;

an electrical umbilical cord that provides electrical power to said all-electric car from the car trailer;

an internal-combustion engine and an associated petrochemical fuel storage mounted to the car trailer;

an electric generator mounted to the car trailer and connected to be driven by the internal-combustion engine, wherein, the electric generator provides battery recharging and operating power to said all-electric car through said umbilical cord;

an electrical-power inverter mounted to the car trailer providing for a conversion of electrical power from the electric generator to a form that is compatible with the all-electric car;

a set of pivotable wheels for carrying the weight of the car trailer over a road;

a double attachment between the car trailer and said all-electric car providing for simplified back-up maneuvers of said all-electric car, wherein such double attachment allows the all-electric car to automatically steer the wheels when traveling;

an automatic control system connected to the internal-combustion engine providing for on-off operation of the electric generator according to an electrical power demand of the all-electric car;

a set of batteries mounted to the car trailer and providing for reserve electrical operating power for the all-electric car;

a general purpose storage compartment mounted to the car trailer and providing space for equipment related to the use of the all-electric car;

a trailer hitch providing for quick and simple mechanical attachment of the car trailer to the all-electric vehicle; and

an electrical connector and cable included in the umbilical cord and providing for quick and simple electrical attachment of the car trailer to the all-electric vehicle.

10. An equipment-rental business model, in which:

a business makes available at least one power-trailer that can be temporarily fitted to an all-electric car; and

a customer rents one such power-trailer from the business for a period of time and attaches it mechanically and electrically to said all-electric car;

wherein, said power-trailer includes an internal-combustion engine that turns an electric generator that provides battery recharging and operating power to said all-electric car through an umbilical cord.

Fig. 1

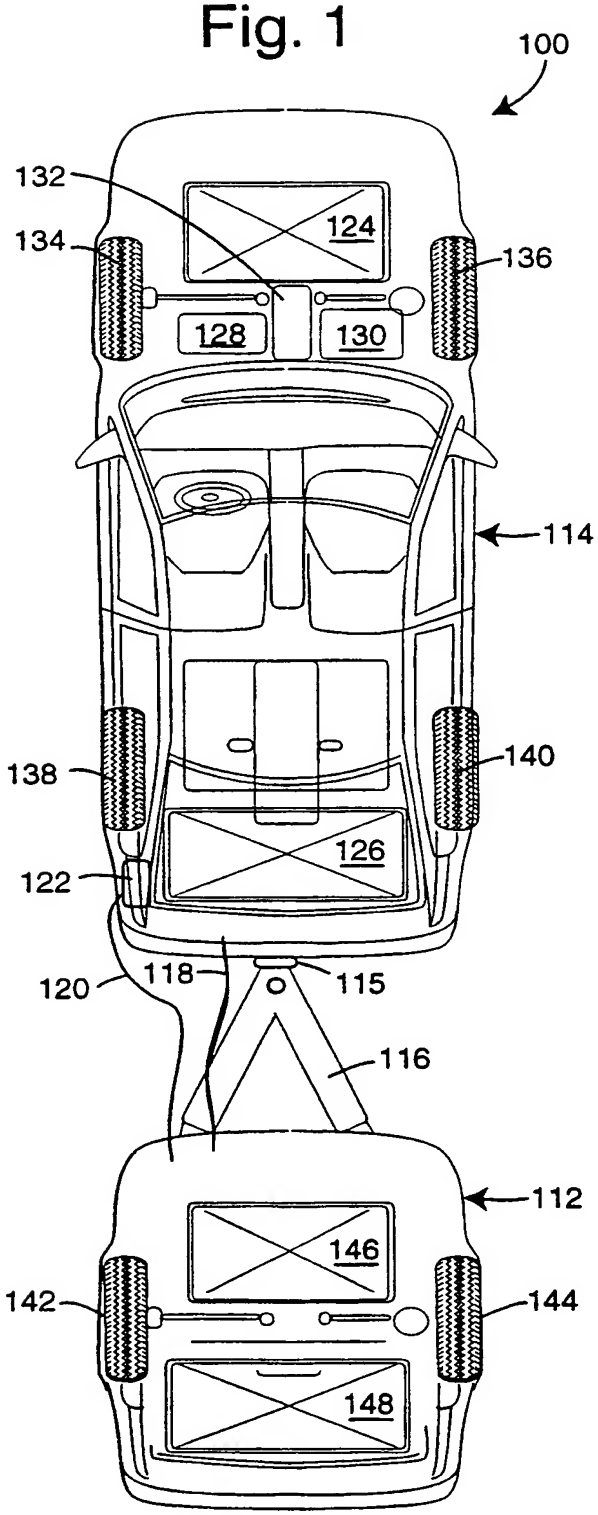
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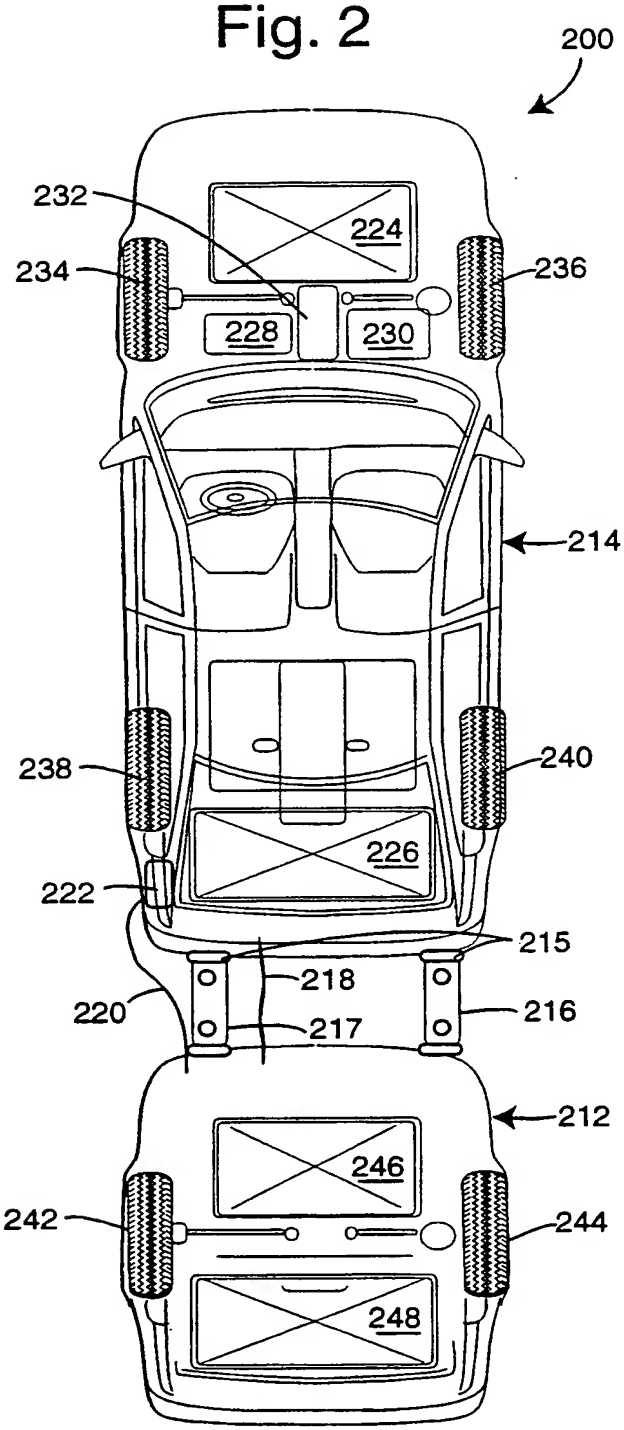
Fig. 2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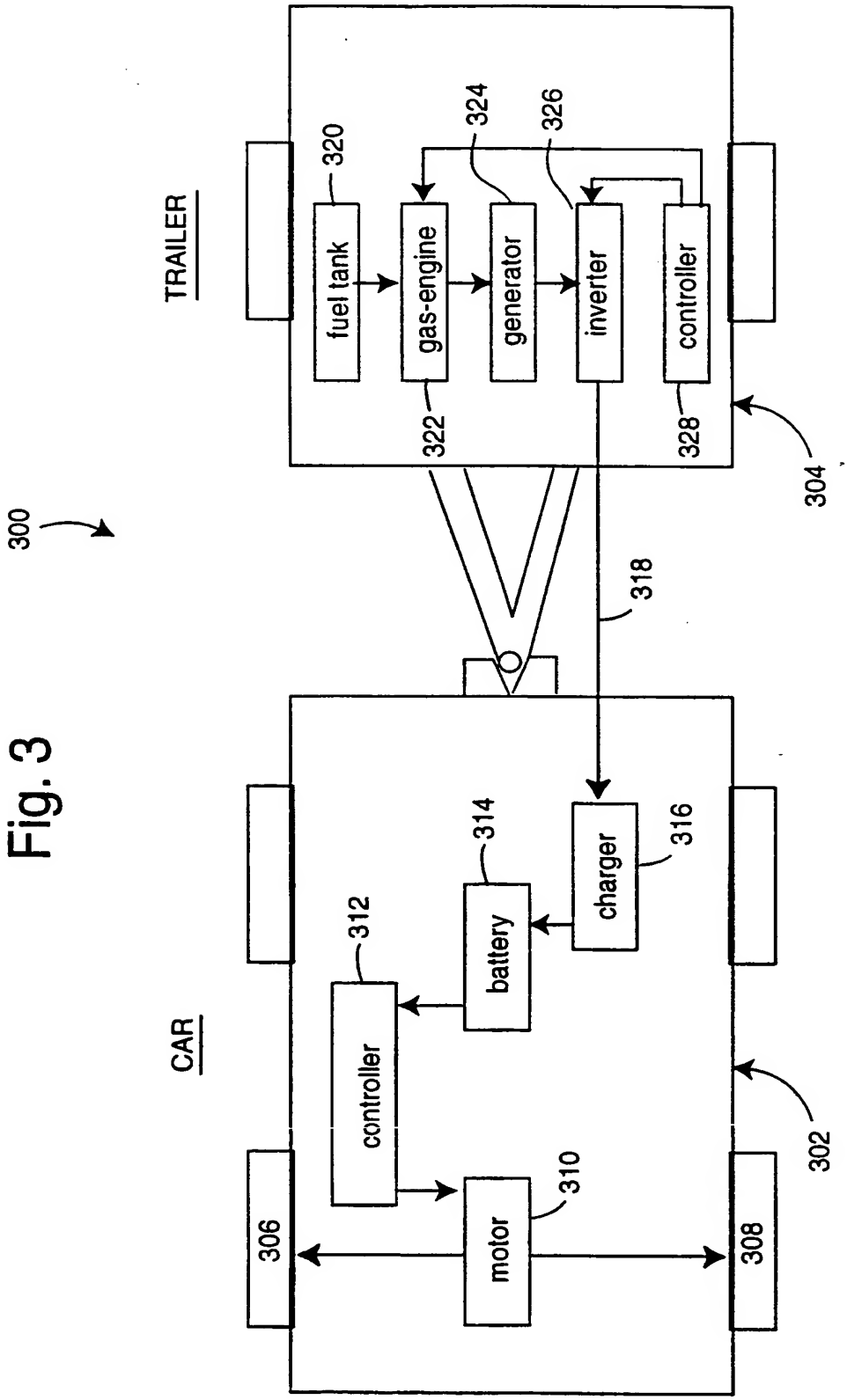
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inverter
controller
322
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CAR
314
battery
316
charger
312
controller
310
motor
306
308
302

Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/40094

A. CLASSIFICATION OF SUBJECT MATTER
IPC(7) : B60K 1/00; B60L 11/12
US CL : 180/65.4, 65.2
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 180/65.4, 65.2, 65.1, 65.3; 318/139, 140

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS
search terms: trailer

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,339,015 A (FOWKES et al) 13 July 1982, col. 1, lines 14-15; col. 4, lines 4-6.	1-10
X	US 4,269,280 A (ROSEN) 26 May 1981, fig. 4.	1-2, 4-7
Y		3, 8-10
X	DE 4032606 A1(THIESEN) 26 March 1992, see abstract.	1-2, 5-7
Y		3-4, 8-10
X	DE 3732869 A1 (KINDLER) 20 April 1989, see abstract.	1-2, 6-7
Y		3-5, 8-10
A	US 5,225,744 A (ISHIKAWA et al) 06 July 1993.	1-10

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
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"O"	document referring to an oral disclosure, use, exhibition or other means		
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Date of the actual completion of the international search	Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/40094

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,199,037 A (WHITE) 22 April 1980, cols. 1-3.	1-10
A	US 3,497,027 A (WILD) 24 February 1970.	1-10
A	US 5,251,721 A (ORTENHEIM) 12 October 1993.	1-10
A	US 3,690,397 A (PARKER) 12 September 1972.	1-10